

Heritability of justice sensitivity

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Abstract

Justice is one of fundamental principles in human evolution, and justice sensitivity, both from the proself perspective (e.g., as victim) and the prosocial perspective (e.g., as observer, beneficiary, and perpetrator), matters in mental wellness and social interaction. However, it remains unclear to what extent individual difference in justice sensitivity is influenced by genetic versus environmental factors. Using a sample with 244 twin pairs, the present research was an attempt to determine what extent genetic factor plays a role in the inter-individual difference of justice sensitivity as well as whether different facets of justice sensitivity, namely, proself and prosocial perspective, share common genetic basis. Results showed that (1) all the four facets of justice sensitivity were moderately heritable (21%–33%) and that the non-shared environmental factors accounted for the rest variations (67%–79%); (2) associations between the prosocial facets of justice sensitivity were driven by common genetics (r_g : .50–.65) and non-shared environmental (r_e : .24–.65) influences, whereas no strong evidence supported a genetic correlation between proself and prosocial justice sensitivity. The current findings provide novel evidence that sensitivity to injustice, especially to others' suffering, is fundamentally grounded upon genetic origin, thus shedding light on the nature and nurture aspects of justice behavior.

Keywords: justice sensitivity, heritability, twin study, behavioral genetics

Introduction

Justice is a crucial force for social stability and has deep evolutionary roots (Wallace, Cesarini, Lichtenstein, & Johannesson, 2007; Buckholtz & Marois, 2012). Given justice matters to all people (Schmitt, Baumert, Gollwitzer, & Maes, 2010), and they are sensitive in reaction to the situations when themselves or others are treated unfairly (Baumert & Schmitt, 2016; Schmitt, 1996; Schmitt & Mohiyeddini, 1996; Schmitt, Neumann, & Montada, 1995). Justice sensitivity is essential for mental health and subjective well-being of individuals (Baumert & Schmitt, 2016). Moreover, justice sensitivity has been taken as a potential factor for the emergence and maintenance of psychiatric disorders which have heritable origins in etiology, such as attention deficit hyperactivity disorder (Bondü & Elsner, 2015), depression (Bondü, Sahyazici-Knaak, & Esser, 2017), and borderline personality disorder (Lis et al., 2018).

However, it remains arguable whether dispositional nature of justice sensitivity is more important than are situational and societal factors for understanding justice principles and behavior (Schmitt, Gollwitzer, Maes, & Arbach, 2005). That is, understanding the origin of justice sensitivity is vital to researches on justice behavior. In the current work, our interest lies in to assess to what extent genetic factor plays a role in the inter-individual difference of justice sensitivity as well as whether different facets of justice sensitivity, namely, for oneself and for others, share common innate and genetic mechanisms.

Individual Differences in Justice Sensitivity

Recent theories assume that justice sensitivity involves a low perceptual threshold for incidents of injustice, strong emotional responses to injustice (anger, outrage, and guilt), tendency to ruminate about injustice, and a motivation to

reestablish justice (Schmitt et al., 2005). Justice sensitivity divides the concern for justice into four facets according to the role a person plays in an unjust situation, namely, as the victim, observer or bystander, passive beneficiary, or active perpetrator (Mikula, Petri, & Tanzer, 1990). The victim is the person who feels unjustly treated, the observer is the one who perceives the incident without being directly involved, the beneficiary is the person who receives the benefit passively, and the perpetrator is the one who committed the critical action (Gollwitzer, Schmitt, Schalke, Maes, & Baer, 2005). On the one hand, these four facets of justice sensitivity can be further distinguished as justice concerns for the self and for others, such that victim sensitivity (VS) involves proself concerns for one's own interest, whereas observer sensitivity (OS), beneficiary sensitivity (BS), and perpetrator sensitivity (PS) involve prosocial concerns for others and public wellbeing. VS is a mixture of self-related concerns and sense of justice, and the remaining three facets have no selfish component but indicate prosocial and genuine justice concerns (Thomas, Baumert, & Schmitt, 2011). On the other hand, the four facets of justice sensitivity appear to overlap, with correlation coefficients ranging from 0.3 to 0.8 (Schmitt et al., 2010), because they share the concern for justice as a common element. Regarding the characteristic emotional responses to injustice, BS and PS share a clear similarity in terms of guilty reactions, whereas VS and OS induce outward-focused emotions, such as anger and moral outrage, respectively (Thomas et al., 2011; for a review, see Baumert & Schmitt, 2016).

Although individual justice sensitivity depends on the adopted perspectives, all four facets of justice sensitivity show a dispositional stability in relation to personality traits, behavioral consequences, and cultural values. For personality traits, the proself facet (VS) is primarily associated with self-related concerns, such as neuroticism,

Machiavellianism, paranoia, suspiciousness, vengeance, and jealousy. By contrast, the prosocial facets (OS, BS, and PS) are primarily associated with others-related concerns, such as agreeableness, role taking, empathy, and social responsibility (Schmitt et al., 2010; Schmitt et al., 2005). For behavioral consequences, OS, BS, and PS positively correlate with positive behavioral reciprocity and negatively with negative behavioral reciprocity. VS negatively correlates with positive behavioral reciprocity and positively correlates with negative behavioral reciprocity (Baumert et al., 2014). In particular, people with high (vs. low) OS contribute more to the public good regardless of past exploitation (Gollwitzer, Rothmund, Pfeiffer, & Ensenbach, 2009). Finally, for cultural values, recent cross-cultural studies reveal that variations in the prosocial facets of justice sensitivity have a stable relation with collectivism not only at the country-level but also at the individual level (Maltese et al., 2018; Wu et al., 2014; Wu et al., 2020).

Biological Origin of Justice Sensitivity

Developmental psychology and behavioral genetics suggest that human nature or genetic factors partly contribute to the individual differences in justice sensitivity. Development studies found that children as young as two years demonstrated preferences for fairness in ultimatum games (Li, Wang, Yu, & Zhu, 2016). A general predisposition towards just evaluations were also observed in 6- and 10-month-old infants who chose and looked longer at an individual who helped another than at one who hindered another (Hamlin, Wynn, & Bloom, 2007; Warneken & Tomasello, 2006). Previous observational research suggested that animals also respond negatively to inequity. For example, chimpanzees responded with temper tantrums if they did not obtain what they desire, social canids refused to play with individuals who violated social rules, and ravens showed third party intervention against norm violations

(Brosnan, 2006; Brosnan & De Waal, 2003). In summary, the appearance of fairness preference in the early stages of life and the inequity response in animals suggest that the intuitive reaction to injustice has deep biological roots. Behavioral genetics studies on twins further suggest that genes moderately influence the fairness-related decision-making behavior (Wallace et al., 2007; Wang et al., 2019) and morality related traits, such as honesty-humility (Kandler, Richter, & Zapko-Willmes, 2019).

However, from the perspective of socialization theory, environmental factors are also found to affect individual differences in justice sensitivity. For example, elder and highly educated people showed a low level of prosocial justice sensitivity and a high level of prosocial justice sensitivity. In addition, compared with Western Germans (Capitalism-oriented), Eastern Germans (Socialism-oriented) showed higher levels of all facets of justice sensitivity (Schmitt et al., 2010). People in collectivist cultures, such as the Chinese, revealed high BS and comparable OS when compared with individualist Germans, Russians, and North Americans (Wu et al., 2014; Wu et al., 2020). Moreover, individuals experimentally primed by collectivist (vs. individualistic) unscrambled-sentence tasks scored high on interdependent self (vs. independent self) and on all three prosocial facets of justice sensitivity (Wu et al., 2020). Similarly, on prosocial facets of justice sensitivity, the collectivist Filipinos scored higher than the individualist Australians (Maltese et al., 2018).

Despite ample experimental evidence, whether the individual variation in justice sensitivity is affected by genetic factor or shaped by environmental experience remains unclear. Theoretically, genetic and environmental factors are both considered to account for the inter-individual differences in personality and behaviors, producing the diversities and uniformities of human nature. However, it is unknown to which extent genetic and environmental factors contribute to the inter-individual differences

in justice sensitivity. Besides, given that justice sensitivity consists of four components and they are positively correlated between each other, it is unknown whether there are common genetic or environmental factors influences the phenotypic correlations between different perspective of justice sensitivity. Therefore, empirical investigation on the extent that nature and nurture contribute to the course of human development in justice sensitivity is still necessary.

The Present Research

To summarize, the current study aims to answer two questions. First, we investigate to what extent genetic and environmental factors play a role in the inter-individual difference of justice sensitivity. Second, we investigate whether different perspective of justice sensitivity shares the common genetic or environmental factors in terms of justice for self and for others. Behavioral genetic work, which is fundamentally about the study of human variation, could provide important clues as to the sources of individual differences (Plomin, DeFries, Knopik, & Neiderhiser, 2013). Specifically, the twin methodology can be used to identify the extent to which individual differences in justice sensitivity are influenced by genetic and environmental factors and to further examine the pairwise genetic and environmental correlations between multiple variables. Therefore, a twin study was conducted to examine the genetic and environmental bases of justice sensitivity and the genetic and environmental associations between different facets of justice sensitivity.

Method

Participants

A total of 244 same-sex twins (133 females, aged 18 to 25, $M = 19.72$, $SD = 1.77$) were recruited to participate in this study, among which 151 pairs were

monozygotic (MZ) and 93 pairs were dizygotic (DZ). The sample was derived from the decision making-brain sub-database, which was built based on the participant pool of the Beijing Twin Study (BeTwiSt) (Bi et al., 2019; Chen et al., 2013). This sub-database was established in 2012 and included psychological traits measures and functional magnetic resonance imaging (fMRI) data, which consisted of 411 and 277 pairs of twins respectively. Some key findings based on this sub-database have been published (Rao, Zhou, Zheng, Yang, & Li, 2018; Wang, Zheng, Xuan, Chen, & Li, 2016; Wang et al., 2019; Zheng, Chen, Wang, & Zhou, 2019). In this study, we included all subjects who completed the Justice Sensitivity Inventory. The zygosity of the twin pairs in the present study was determined via DNA testing. The ethics committee provided approval for the study. Additionally, we obtained written informed consent from all participants prior to commencing the study.

Measures

The Chinese version of the Justice Sensitivity Inventory was used to assess participants' sensitivity to injustice (Schmitt et al., 2010; Wu et al., 2014). Each subscale contains 10 items that measure a single facet: VS (e.g., "It makes me angry when I am undeservingly worse off than others"), OS (e.g., "I am upset when someone is undeservingly worse off than others"), BS (e.g., "I feel guilty when I am better off than others for no reason"), and PS (e.g., "I feel guilty when I enrich myself at the cost of others"). Participants responded to the items on a 0–5 Likert scale (0 = not at all, 5 = exactly), with high scores indicating high sensitivity to injustice from the victim, observer, beneficiary, and perpetrator perspectives. Individual scores were obtained by averaging the items of the relevant subscale. The estimated reliabilities (Cronbach's α) of the four facets of justice sensitivity were .83 for VS, .90 for OS, .85 for BS, and .89 for PS, respectively.

Data Analysis

By comparing the resemblance of the MZ and DZ twin pairs on observed trait(s), we can estimate additive genetic (A), shared environmental (C), and non-shared environmental (E) contributions to variance within a trait and covariance between traits (Plomin et al., 2013). MZ twins are 100% genetically identical, whereas DZ twins are, on average, 50% identical for additive genetic effects. In the usual case where twins are reared together, the greater resemblance between MZ twins than between DZ twins indicates that the trait is heritable. The proportion of the trait variance or covariance between traits as explained by additive genetic effects is referred to as “heritability.” A shared environment contributes to the similarity of twins growing up in the same family. A non-shared environment is unique to each individual, which likewise includes measurement error.

Twins are perfectly correlated for age and same-sex twins are perfectly correlated for sex. Thus, variation associated with age or sex would inflate the correlation between twins. We separately regressed each facet of justice sensitivity onto sex and age, and then saved the standardized residuals for genetic analyses. Participants who scored 3 SD beyond the mean value of the entire sample were excluded from further analyses. The numbers of excluded participants were three for VS, two for OS, one for BS, and four for PS, respectively. To increase the statistical power of genetic model-fitting, we used all available data, including those from several twin pairs who were not pairwise.

Univariate and bivariate models were implemented in the OpenMx package for R version 3.0.1 to estimate genetic and environmental effects. First, univariate models were used to partition the variance of each dimension into genetic (A) and environmental (C and E) effects. For each dimension, the full ACE model was

examined first. Sub-models (AE, CE, and E) nested within the full model were then tested by systematically removing one or two variance component(s). Next, for the bivariate analyses of each paired facets, a correlated factors model was used (Loehlin, 1996) (*Figure 1*), wherein each variable was separately decomposed into ACE components. Meanwhile, the correlations of these components across variables were estimated. The full ACE model and all of the sub-models were systematically tested.

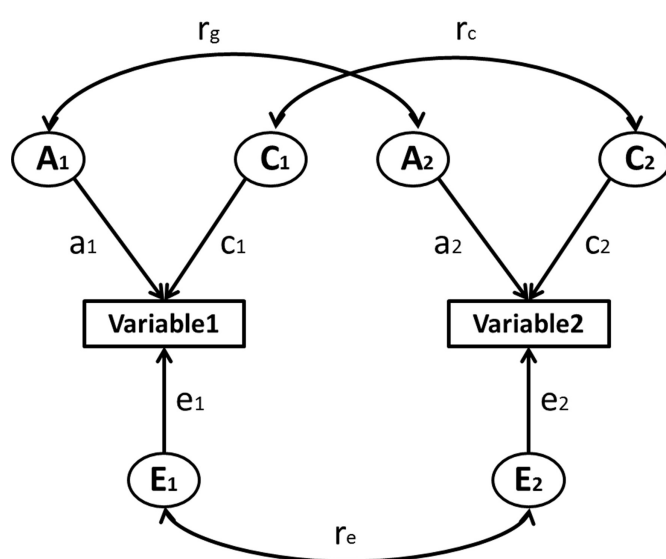


Figure 1. Path diagram illustrating bivariate genetic model-fitting. Measured variables are in rectangles. Latent factors A (genetic factors), C (shared environmental factors) and E (non-shared environmental factors) are in circles. r_g : genetic correlation; r_c : shared environmental correlation; r_e : non-shared environmental correlation.

We used three model fit indices: the change in chi-square (χ^2), Akaike's Information Criterion (AIC) (Akaike, 1987), and Bayesian Information Criterion (BIC) (Raftery, 1995). Comparing the full model with a sub-model, a significant chi-square difference suggests that the nested model fits significantly worse than the full model, and thus the full model should be chosen; otherwise, the nested model with fewer parameters should be considered in terms of parsimony (Bollen, 1989; Kline, 1998). Both AIC and BIC are useful in model selection, with low values indicating

better fit than high values. In model selection, Raftery (1993) suggested that a BIC difference of 5 indicates “strong evidence” that one model is superior to another, whereas a difference of 10 indicates “conclusive evidence” (Raftery, 1993). Ultimately, the better-fitting model received due consideration (Kline, 1998).

Statistical Power for Genetic Analyses

In order to gauge whether we had sufficient power to detect genetic or environmental effects, we estimated the minimum effect size that could be reliably observed within the current sample. We implemented the power analysis via the package “pwr” in R (Champely, 2018), which functions along the lines of Cohen (1988). Given a sample size of $N = 241/243$ (the total number of twin pairs; Table 1), level of significance at $.10^1$, degrees of freedom (df) at 1 (estimating one effect each time), and power at the conventional level of .80, we could detect effects whose size (w) was no less than $.16^2$. Put otherwise, if the standardized estimate of a path parameter in the genetic model (e.g., A in univariate model or $a1$ in bivariate model) were no less than .16, we would have sufficient power to examine the corresponding genetic or environmental effects. This kind of method that estimating statistical power for genetic analyses has been successfully adopted by Luo et al., (2020).

Results

Table 1 showed mean scores and standard deviations for each facet of justice sensitivity. In addition, as shown in *Table 1*, the prosself facet of justice sensitivity (VS) was significantly and positively correlated with the prosocial facets of justice

1 For power analyses of twin models, Verhulst (2017) recommends setting Type I Error rate as .10 to address a complex situation involving multiple chi-square distributions with different dfs . Such a solution is adequate for 1 df test but may lead to an underestimate power for multiple df test. Nevertheless, we adopted this conservative strategy in our power analyses.

2 Cohen (1988) suggests that w is comparable to the conventional effect size r , and that w values of 0.1, 0.3, and 0.5 represent small, medium, and large effect sizes, respectively.

sensitivity (OS and BS). The correlations between each pair of prosocial facets (OS, BS, and PS) were likewise positively significant. The correlation between VS and PS was positive but not significant. The correlation pattern replicated the findings in previous studies. Typically, the correlation between BS and PS is the highest and that between VS and PS is the lowest (Schmitt et al., 2010).

Table 1. Means for, zero-order correlations among, and twin intraclass correlations for all measures.

Measure	Mean	SD	Zero-Order Correlation			Twin correlations			
			VS	OS	BS	ICC _{MZ}	N _{MZ}	ICC _{DZ}	N _{DZ}
VS	2.71	0.71				.48***	150	-.10	91
OS	2.29	0.83	.37***			.42***	150	-.08	93
BS	2.82	0.79	.17***	.53***		.51***	151	.33*	92
PS	3.45	0.79	.08	.31***	.61***	.36***	150	.17	91

Note. VS: Victim Sensitivity; OS: Observer Sensitivity; BS: Beneficiary Sensitivity; PS: Perpetrator Sensitivity; ICC: intraclass correlation; *** $p < .001$, * $p < .05$; MZ: monozygotic twins; DZ: dizygotic twins; N: number of twin pairs.

Univariate Model Fitting

For all the four facets of justice sensitivity, MZ twin correlations were significantly higher than DZ correlations (*Table 1*), suggesting that genes substantially contribute to individual differences in terms of sensitivity to injustice. Thereafter, the heritability of each facet was examined by fitting a series of univariate models. In comparison with the ACE model, the E model fit significantly worse for each facet of justice sensitivity ($\Delta\chi^2s \geq 7.16$, $ps \leq .03$), the AE model fit equally well for VS, OS, and PS ($\Delta\chi^2s = 0.00$, $ps = 1.00$), and the AE and CE models each fit equally well for BS ($\Delta\chi^2s \leq 0.92$, $ps \geq .34$). Therefore, the nested model with fewer parameters (AE/CE) should be considered in terms of parsimony (Bollen, 1989; Kline, 1998). Finally, the AE model was considered more desirable because its AIC and BIC values were smaller than those of the CE model for each facet (*Table 2*). As shown in *Table*

2, univariate model fitting revealed moderate heritability for each facet (27% for VS, 21% for OS, 33% for BS, and 23% for PS) and large non-shared environmental effects (73% for VS, 79% for OS, 67% for BS, and 77% for PS). Importantly, the magnitude of all the genetic and non-shared environmental effects was above the minimal effect size (.16) that we can detect with sufficient power.

Table 2. Univariate genetic model-fitting.

Measure	Model	-2LL	df	AIC	BIC	Change from full model			A	C	E
						$\Delta\chi^2$	Δdf	p			
VS	ACE	1026.88	481	64.88	-1617.26				.27 (.02, .40)	.00 (.00, .19)	.73 (.60, .88)
	<u>AE</u>	1026.88	482	62.88	-1622.75	0.00	1	1.00	.27 (.12, .40)		.73 (.60, .88)
	CE	1031.22	482	67.22	-1618.42	4.33	1	.04		.18 (.06, .30)	.82 (.70, .94)
	E	1039.58	483	73.57	-1615.56	12.69	2	.00			1.00 (1.00, 1.00)
OS	ACE	1186.66	482	222.66	-1462.97				.21 (.00, .36)	.00 (.00, .19)	.79 (.64, .94)
	<u>AE</u>	1186.66	483	220.66	-1468.47	0.00	1	1.00	.21 (.06, .36)		.79 (.64, .94)
	CE	1189.70	483	223.70	-1465.44	3.03	1	.08		.13 (.00, .25)	.87 (.75, 1.00)
	E	1193.82	484	225.82	-1466.81	7.16	2	.03			1.00 (1.00, 1.00)
BS	ACE	1358.97	483	392.97	-1296.16				.23 (.00, .45)	.09 (.00, .38)	.68 (.55, .82)
	<u>AE</u>	1359.13	484	391.13	-1301.50	0.16	1	.69	.33 (.19, .45)		.67 (.55, .81)
	CE	1359.89	484	391.89	-1300.74	0.92	1	.34		.28 (.16, .39)	.72 (.61, .84)
	E	1380.04	485	410.04	-1286.08	21.07	2	.00			1.00 (1.00, 1.00)
PS	ACE	1363.24	480	403.24	-1275.40				.23 (.00, .37)	.00 (.00, .27)	.77 (.63, .93)
	<u>AE</u>	1363.24	481	401.24	-1280.90	0.00	1	1.00	.23 (.07, .37)		.77 (.63, .93)
	CE	1364.58	481	402.58	-1279.56	1.34	1	.25		.17 (.04, .29)	.83 (.71, .96)
	E	1371.53	482	407.53	-1278.11	8.29	2	.02			1.00(1.00, 1.00)

Note. VS: Victim Sensitivity; OS: Observer Sensitivity; BS: Beneficiary Sensitivity;

PS: Perpetrator Sensitivity. The full ACE model and the best-fitting model are presented for each component. -2LL: twice the negative log-likelihood; AIC: Akaike information criterion; $\Delta\chi^2$: change in chi-square; Δdf : change in degrees of freedom (df); A: proportion of variance due to additive genetic effects; C: proportion of variance due to shared environmental effects; E: proportion of variance due to non-shared environmental effects; 95% confidence intervals are in parentheses. The best-fitting model is underlined.

Bivariate Model Fitting

Bivariate modeling analyses were conducted using correlated-factors models to explore the extent of covariation between each pair of justice sensitivity facets (OS–BS, OS–PS, BS–PS, VS–OS, and VS–BS) due to genetic and environmental factors.

OS and BS: We tested the full ACE model first and thereafter the AE, CE, and E models (*Table 3*). Compared with the ACE model, the AE and CE models each fit equally well ($\Delta\chi^2s \leq 3.44$, $ps \geq .33$) but the E model fit significantly worse ($\Delta\chi^2 = 27.80$, $p = .00$). The AE model was deemed preferable because its AIC and BIC values were smaller than those of the CE model (*Figure 2a*) (Bollen, 1989; Kline, 1998; Raftery, 1993). In the AE model, genes that influenced OS also moderately influenced BS ($r_g = .65$), whereas non-shared environments that affected OS also had a significant impact on BS ($r_e = .49$).

OS and PS: As shown in *Table 3*, the correlated-factors model with only genetic and non-shared environmental components (i.e., AE model, *Figure 2b*) provided the best fit for the data ($\Delta\chi^2 = 0.55$, $p = .91$). OS and PS shared the moderate genetic ($r_g = .58$) and non-shared environmental ($r_e = .24$) correlations.

BS and PS: As shown in *Table 3*, the correlated-factors model with only genetic and non-shared environmental components (i.e., AE model, *Figure 2c*) provided the best fit for the data ($\Delta\chi^2 = 1.24$, $p = .74$). In the AE model, BS and PS shared moderate genetic ($r_g = .50$) and non-shared environmental ($r_e = .65$) correlations.

VS and OS: The same model analysis was conducted for VS and OS. As seen in *Table 3*, the AE model was optimal ($\Delta\chi^2 = 0.00$, $p = 1.00$). In the AE model, VS and OS shared modest genetic ($r_g = .21$) and non-shared environmental ($r_e = .42$) correlations. Notably, the 95% confidence interval of the genetic correlation ($-.45$ to $.58$) included zero (*Figure 2d*). Thus, no sufficient evidence was found to support a genetic correlation between VS and OS.

VS and BS: As seen in *Table 3*, the AE model provided the best fit for the data ($\Delta\chi^2 = 0.18$, $p = .98$). In the AE model, VS and BS shared minimal genetic correlation ($r_g = .07$) and modest non-shared environmental correlation ($r_e = .21$). Notably, the 95% confidence interval of the genetic correlation ($-.35$ to $.41$) included zero (*Figure 2e*). Thus, no sufficient evidence was observed to support a genetic correlation between VS and BS.

In summary, the prosocial facets of justice sensitivity correlated with each other in the genetic and environmental factors and the magnitude of all the genetic and non-shared environmental effects was above the minimal effect size (.16) that we can detect with sufficient power. However, the genetic correlation between the prosocial facet of justice sensitivity was not significant. This analysis provides further evidence for the distinction between justice sensitivity for one's self and for others.

Table 3. Bivariate genetic model-fitting.

Measure	Model	-2LL	df	AIC	BIC	Change from full model		
						$\Delta\chi^2$	Δdf	p
OS-BS	ACE	2388.19	962	464.19	-2900.09			
	<u>AE</u>	2389.99	965	459.99	-2914.78	1.8	3	.61
	CE	2391.63	965	461.63	-2913.14	3.44	3	.33
	E	2415.99	968	479.99	-2905.27	27.80	6	.00
OS-PS	ACE	2501.36	959	583.36	-2770.42			
	<u>AE</u>	2501.91	962	577.91	-2786.36	0.55	3	.91
	CE	2505.80	962	581.80	-2782.48	4.44	3	.22
	E	2516.49	965	586.49	-2788.28	15.13	6	.02
BS-PS	ACE	2494.58	960	574.58	-2782.70			
	<u>AE</u>	2495.82	963	569.82	-2797.95	1.24	3	.74
	CE	2496.24	963	570.24	-2797.54	1.65	3	.65
	E	2530.97	966	598.97	-2779.29	36.39	6	.00
VS-OS	ACE	2138.61	960	218.61	-3138.67			
	<u>AE</u>	2138.61	963	212.61	-3155.17	0	3	1.00
	CE	2145.04	963	219.04	-3148.73	6.43	3	.09
	E	2161.72	966	229.72	-3148.54	23.12	6	.00
VS-BS	ACE	2370.37	961	448.37	-2912.41			
	<u>AE</u>	2370.55	964	442.55	-2928.72	0.18	3	.98
	CE	2384.55	964	456.55	-2914.72	14.18	3	.00
	E	2405.91	967	471.91	-2909.85	35.54	6	.00

Note: VS: Victim Sensitivity; OS: Observer Sensitivity; BS: Beneficiary Sensitivity; PS: Perpetrator Sensitivity. The full ACE model and the best-fitting model are presented for each component. -2LL: twice the negative log-likelihood; AIC: Akaike information criterion; $\Delta\chi^2$: change in chi-square; Δdf : change in degrees of freedom (df); A: proportion of variance due to additive genetic effects; C: proportion of variance due to shared environmental effects; E: proportion of variance due to non-shared environmental effects; 95% confidence intervals are in parentheses. The best-fitting model is underlined.

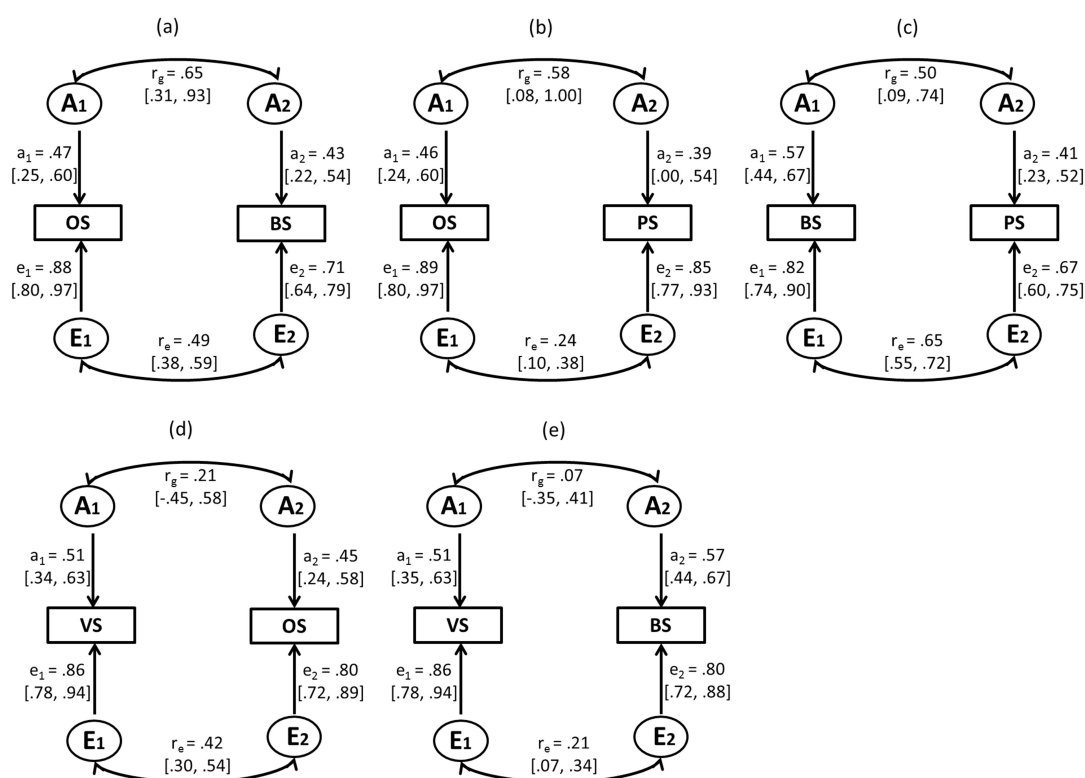


Figure 2. Best-fitting bivariate genetic models: (a) best-fitting model for OS and BS; (b) best-fitting model for OS and PS; (c) best-fitting model for BS and PS; (d) the best-fitting model for VS and OS; (e) best-fitting model for VS and BS. VS: Victim Sensitivity; OS: Observer Sensitivity; BS: Beneficiary Sensitivity; PS: Perpetrator Sensitivity. Measured variables are in rectangles. Latent factors A (additive genetic factors) and E (non-shared environmental factors) are in circles. r_g : genetic

correlation; r_e : non-shared environmental correlation. All path estimates (95% confidence intervals), standardized but unsquared, are obtained from the best-fitting model.

Discussion

Justice is a fundamental concern of human societies and also a critical component of morality. From an early age, individuals are motivated by considerations of justice such as fairness and equity for both themselves and for others. Despite robust evidence that the desire for justice may be universal, numerous studies have revealed that individuals differ in their reactions to injustices, especially from different perspectives. Hypersensitivity to injustice has been proposed to contribute to the emergence and maintenance of several most common mental disorders (Bondü & Elsner, 2015; Bondü, Sahyazici-Knaak, & Esser, 2017; Lis et al., 2018). With such consideration, we examined the genetic contribution to justice sensitivity variations and the genetic associations between different facets of justice sensitivity using twins. The current results identified modest genetic contributions (21%–33%) and large non-shared environmental contributions (67%–79%) to justice sensitivity. The shared environmental contribution to justice sensitivity was minimal. More importantly, moderate genetic (.50–.65) and non-shared environmental (.24–.65) correlations were found among the prosocial facets of justice sensitivity (OS, BS, and PS), whereas no strong evidence supported a genetic correlation between proself and prosocial justice sensitivity. These findings thus provide novel evidence about the genetic basis of justice sensitivity and the associations between different facets of prosocial of justice sensitivity.

The results support our hypothesis that both the nurture and nature aspects play

important roles in the development of individual differences in justice sensitivity. Studies have uncovered the heritability of numerous attitudes (Olson, Vernon, Harris, & Jang, 2001) and various aspects of social behavior (Ebstein, Israel, Chew, Zhong, & Knafo, 2010), such as fairness-related decisions (Cesarini et al., 2008; Wallace et al., 2007; Wang et al., 2019). In the current study, the identified heritability of justice sensitivity shows implications for understanding individual differences in sensitivity to injustice. Individuals differ in how readily they perceive and how strongly they react to injustice. Several systematic examinations focused on individual differences in the emotions and behaviors that result from experiencing or witnessing injustice (Baumert & Schmitt, 2016; Schmitt, 1996; Schmitt et al., 2010; Schmitt et al., 2005). On the basis of such previous investigations, the present study moves a step forward by conducting a behavioral genetics study on twins and finds moderate justice sensitivity heritability and large non-shared environmental influence for all facets of justice sensitivity. These findings provide novel evidence that justice sensitivity is fundamental trait with reliable genetic basis and environmental influences, thereby shedding light on the nature and nurture aspects of justice and morality.

A series of studies have documented the associations between the four facets of justice sensitivity (Gollwitzer et al., 2005; Schmitt et al., 2010). In line with the previous findings, we observed significant correlations for each paired facets of justice sensitivity except for VS and PS. More importantly, the associations between each pair of prosocial justice sensitivity (OS, BS, and PS) were found to be partly due to genetic factors, although non-shared environments likewise play a role. This discovery implies an overlap of the genes and non-shared environments that influence the three facets of prosocial justice sensitivity and provides evidence for the inherent nature behind these links. These findings are consistent with the previous view that

individuals with observer, beneficiary, and perpetrator sensitivities share a genuine concern for justice, whereas those with victim sensitivity have self-related concerns (Thomas et al., 2011). Based on the self–others distinction of justice sensitivity in terms of personality, behavior, and cultural values (Gollwitzer et al., 2005; Schmitt et al., 2010; Wu et al., 2011), our findings provide biological evidence for the homogeneity of prosocial justice sensitivity for others. Specifically, our findings indicate that exploring the common genetic influences underlying prosocial facets is important in understanding the links between justice and morality.

Furthermore, in the AE models, non-shared environmental factors contribute to all the facets of justice sensitivity more so than genetic factors. For BS and PS, the CE models (shared and non-shared environmental factors) are also workable. These findings suggest that, although genetic factors are significant in explaining the justice sensitivity variations, shared and non-shared environmental factors should likewise be considered. On the one hand, in the twin analysis, non-shared environmental factors are often related to the macro-level societies, such as ecological environment, social structure, and cultural values, all of which play a significant role in the socialization of justice sensitivity. For example, social institutions and cultural values have been found to account for group differences in justice sensitivity among Eastern versus Western Germans (Schmitt et al., 2010), Chinese versus Germans, Russians, and North Americans (Wu et al., 2014; Wu et al., 2020), and Filipinos versus Australians (Maltese et al., 2018). Even a spontaneous priming of collectivism vs. individualism can promote prosocial justice sensitivity (Wu et al., 2020). On the other hand, shared environmental factors that are often related to micro-level societies, such as family, were found to be predictable in the CE models of BS (28%) and PS (17%). Although the family effect on BS and PS has not been tested, a few studies suggested that

parenting style (restrictive vs. nurturant) affects the development of inhibition-based moral orientations (Janoff-Bulman, Carnes, & Sheikh, 2014). Given that BS and PS are inhibition-based (Wu, 2014), for which people should not take advantage of others (as a beneficiary) or do evil (as perpetrator), further research is necessary to test the effects of restrictive parenting on the development of BS and PS. In addition, a more recent investigation revealed that compared with upper class, low class (indicated by low family income) scored higher on prosocial justice sensitivity, especially for BS and PS (Wu, Wang, Chen, & Zhou, 2020).

This study has several limitations. First, the twin participants were young adults. Previous studies found that in comparison, older participants scored significantly higher on justice sensitivity for others and lower on justice sensitivity for self (Schmitt et al., 2010; Wu et al., 2020). Thus, our young adult participants may not be a representative sample of the general population. Second, our study only included a Chinese sample. Recent cross-cultural studies compared justice sensitivity across countries in terms of collectivism–individualism and found that people in collectivist cultures scored higher on prosocial facets than those in individualist cultures (Maltese et al., 2018; Wu et al., 2014; Wu et al., 2020). Thus, our results from the Chinese sample may not necessarily be generalizable to other populations. Third, we used the classic ACE models, which treated genetic, shared and non-shared environmental effects as independent. This ignores the possibility that genetic and environmental factors may correlate or interact with each other in complex ways (Purcell, 2002). Such correlations or interactions are critical for gaining nuanced knowledge about the origins of justice sensitivity. Future investigations might include measures of environments to test for potential interactions or correlations with genes. Lastly, our sample was moderate in size. This entailed wide confidence intervals for model

parameters and limited statistical power to detect small genetic or environmental effects, especially shared environmental effects (Verhulst, 2017). Indeed, the magnitude of several shared environmental effects (Table 2), was below the minimal effect size (.16) that we can detect with sufficient power. Thus, future studies must investigate and further verify the heritability of justice sensitivity by extending the sample size and the scope of participant pools.

Justice principles play a dominant role in social interaction and justice sensitivity is important for human well-being and mental health. The origin of individual differences in justice sensitivity and the links between different facets of justice sensitivity are still elusive. By using twin methodology, the present study is the first to partition genetic and environmental influences on justice sensitivity across the four facets (VS, OS, BS, and PS) and to comprehensively examine the genetic associations between them. Overall, the results highlight the roles of additive genetic and non-shared environmental factors in shaping individuals' sensitivity to injustice. Genetic overlaps among prosocial concerns for others are also revealed. As the first genetic study on justice sensitivity, we believe that our findings can shed light on the nature of justice sensitivity and provide additional evidence for understanding proself and prosocial facets of justice sensitivity.

References

- Akaike, H. (1987). Factor-analysis and aic. *Psychometrika*, 52, 317-332.
- Baumert, A., Beierlein, C., Schmitt, M., Kemper, C. J., Kovaleva, A., Liebig, S., & Rammstedt, B. (2014). Measuring four perspectives of justice sensitivity with two items each. *Journal of Personality Assessment*, 96(3), 380-390.
- Baumert, A., & Schmitt, M. (2016). Justice sensitivity. In *Handbook of social justice theory and research* (pp. 161-180). New York: Springer.
- Bi, D., Li, X., Chen, J., Jiang, N., & Zhang, J. (2019). The Beijing Twin Study (BeTwiSt): An Update. *Twin Research and Human Genetics*, 1-6.
- Bollen, K. A. (1989). A new incremental fit index for general structural equation models. *Sociological Methods & Research*, 17(3), 303-316.
- Bondü, R., & Elsner, B. (2015). Justice sensitivity in childhood and adolescence. *Social Development*, 24(2), 420-441.
- Bondü, R., Sahyazici-Knaak, F., & Esser, G. (2017). Long-term associations of justice sensitivity, rejection sensitivity, and depressive symptoms in children and adolescents. *Frontiers in psychology*, 8, 1446.
- Brosnan, S. F. (2006). Nonhuman species' reactions to inequity and their implications for fairness. *Social Justice Research*, 19(2), 153-185.
- Brosnan, S. F., & De Waal, F. B. (2003). Monkeys reject unequal pay. *Nature*, 425(6955), 297.
- Buckholtz, J. W., & Marois, R. (2012). The roots of modern justice: cognitive and neural foundations of social norms and their enforcement. *Nature neuroscience*, 15(5), 655-661.
- Cesarini, D., Dawes, C. T., Fowler, J. H., Johannesson, M., Lichtenstein, P., & Wallace, B. (2008). Heritability of cooperative behavior in the trust game.

Proceedings of the National Academy of Sciences, 105(10), 3721-3726.

Champely, S. (2018). *pwr: Basic Functions for Power Analysis (Version 1.2-2) [R]*.

Retrieved from <https://cran.r-project.org/web/packages/pwr/index.html>

Chen, J., Li, X., Zhang, J., Natsuaki, M. N., Leve, L. D., Harold, G. T., . . . Zhang, J.

(2013). The Beijing Twin Study (BeTwiSt): A longitudinal study of child and adolescent development. *Twin Research and Human Genetics*, 16(1), 91-97.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.)*.

Hillsdale, NJ: Erlbaum.

Ebstein, R. P., Israel, S., Chew, S. H., Zhong, S., & Knafo, A. (2010). Genetics of human social behavior. *Neuron*, 65(6), 831-844.

Gollwitzer, M., Rothmund, T., Pfeiffer, A., & Ensenbach, C. (2009). Why and when justice sensitivity leads to pro-and antisocial behavior. *Journal of Research in Personality*, 43(6), 999-1005.

Gollwitzer, M., Schmitt, M., Schalke, R., Maes, J., & Baer, A. (2005). Asymmetrical effects of justice sensitivity perspectives on prosocial and antisocial behavior. *Social Justice Research*, 18(2), 183-201.

Hamlin, J. K., Wynn, K., & Bloom, P. (2007). Social evaluation by preverbal infants. *Nature*, 450(7169), 557.

Janoff-Bulman, R., Carnes, N. C., & Sheikh, S. (2014). Parenting and politics: Exploring early moral bases of political orientation. *Journal of Social and Political Psychology*, 2, 43-60.

Kandler, C., Richter, J., & Zapko-Willmes, A. (2019). The Nature and Nurture of HEXACO Personality Trait Differences. *Zeitschrift für Psychologie*, 227(3), 195–206.

Kline, R. B. (1998). Software review: Software programs for structural equation

modeling: Amos, EQS, and LISREL. *Journal of Psychoeducational Assessment*, 16(4), 343-364.

Li, J., Wang, W., Yu, J., & Zhu, L. (2016). Young children's development of fairness preference. *Frontiers in psychology*, 7, 1274.

Lis, S., Schaedler, A., Liebke, L., Hauschild, S., Thome, J., Schmahl, C., ... & Bohus, M. (2018). Borderline personality disorder features and sensitivity to injustice. *Journal of personality disorders*, 32(2), 192-206.

Loehlin, J. C. (1996). The Cholesky approach: A cautionary note. *Behavior genetics*, 26(1), 65-69.

Luo, Y. L., Sedikides, C., & Cai, H. (2020). On the etiology of self-enhancement and its association with psychological wellbeing. *Social Psychological and Personality Science*, 11(4), 435-445.

Maltese, S., Baumert, A., Reis, D., MacLeod, C., Tan-Mansukhani, R., Galang, A. J. R., . . . Schmitt, M. (2018). *A cross-cultural study of sensitivity to injustice and its consequences for cooperation*. Paper presented at the the 17th biennial meeting of the International Society for Justice Research (ISJR), Atlanta, United States of America.

Mikula, G., Petri, B., & Tanzer, N. (1990). What people regard as unjust: Types and structures of everyday experiences of injustice. *European journal of social psychology*, 20(2), 133-149.

Olson, J. M., Vernon, P. A., Harris, J. A., & Jang, K. L. (2001). The heritability of attitudes: a study of twins. *Journal of personality and social psychology*, 80(6), 845.

Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. (2013). *Behavioral genetics (6th ed.)*. New York: Worth Publishers.

- Purcell, S. (2002). Variance components models for gene–environment interaction in twin analysis. *Twin Research*, 5, 554-571.
- Raftery, A. E. (1993). Bayesian model selection in structural equation models. *Sage Focus Editions*, 154, 163-163.
- Raftery, A. E. (1995). Bayesian model selection in social research. *Sociological Methodology*, 25, 111-163.
- Rao, L., Zhou, Y., Zheng, D., Yang, L., & Li, S. (2018). Genetic Contribution to Variation in Risk Taking: A Functional MRI Twin Study of the Balloon Analogue Risk Task. *Psychological Science*, 29(10), 1679-1691.
- Schmitt, M. (1996). Individual differences in sensitivity to befallen injustice (SBI). *Personality and individual differences*, 21(1), 3-20.
- Schmitt, M., Baumert, A., Gollwitzer, M., & Maes, J. (2010). The justice sensitivity inventory: Factorial validity, location in the personality facet space, demographic pattern, and normative data. *Social Justice Research*, 23(2-3), 211-238.
- Schmitt, M., Gollwitzer, M., Maes, J., & Arbach, D. (2005). Justice sensitivity. *European Journal of Psychological Assessment*, 21(3), 202-211.
- Schmitt, M. J., & Mohiyeddini, C. (1996). Sensitivity to befallen injustice and reactions to a real-life disadvantage. *Social Justice Research*, 9(3), 223-238.
- Schmitt, M. J., Neumann, R., & Montada, L. (1995). Dispositional sensitivity to befallen injustice. *Social Justice Research*, 8(4), 385-407.
- Thomas, N., Baumert, A., & Schmitt, M. (2011). Justice sensitivity as a risk and protective factor in social conflicts *Justice and conflicts* (pp. 107-120). Berlin, Heidelberg: Springer.
- Verhulst, B. (2017). A power calculator for the classical twin design. *Behavior*

genetics, 47(2), 255-261.

- Wallace, B., Cesarini, D., Lichtenstein, P., & Johannesson, M. (2007). Heritability of ultimatum game responder behavior. *Proceedings of the National Academy of Sciences*, 104(40), 15631-15634.
- Wang, X. T., Zheng, R., Xuan, Y., Chen, J., & Li, S. (2016). Not all risks are created equal: A twin study and meta-analyses of risk taking across seven domains. *Journal of Experimental Psychology: General*, 145(11), 1548-1560.
- Wang, Y., Zheng, D., Chen, J., Rao, L-L., Li, S., & Zhou, Y. (2019). Born for fairness: Evidence of genetic contribution to a neural basis of fairness intuition. *Social cognitive and affective neuroscience*, 14(5), 539-548.
- Warneken, F., & Tomasello, M. (2006). Altruistic helping in human infants and young chimpanzees. *Science*, 311, 1301-1303.
- Wu, M. S. (2014, June 19-22). *Feeling failures of moral motivation: Behavior activation versus inhibition and two classes of justice sensitivity*. Paper presented at the 15th Biennial Conference of The International Society for Justice Research, New York, US.
- Wu, M. S., Schmitt, M., Zhou, C., Nartova-Bochaver, S., Astanina, N., Khachatryan, N., & Han, B. X. (2014). Examining self-advantage in the suffering of others: Cross-cultural differences in beneficiary and observer justice sensitivity among Chinese, Germans, and Russians. *Social Justice Research*, 27(2), 231-242.
- Wu, M. S., Wang, P. L., Chen, Y., & Zhou, C. (2020). Social class and prosocial justice sensitivity: The moderation effect of individualism. *Chinese Social Psychological Review*, 17, 204-214.
- Wu, M. S., Yan, X. D., Zhou, C., Chen, Y. W., Li, J., Zhu, Z. H., . . . Han, B. X.

(2011). General belief in a just world and resilience: Evidence from a collectivistic culture. *European Journal of Personality*, 25(6), 431-442.

Wu, M. S., Zhou, C., Nudelman, G., Wan, R. L., Chen, Y. Y., & Schmitt, M. (2020). Prosocial Justice Sensitivity: Through the Lens of Cultural Norms in China and in the US. Manuscript under review.

Zheng, D., Chen, J., Wang, X., & Zhou, Y. (2019). Genetic contribution to the phenotypic correlation between trait impulsivity and resting-state functional connectivity of the amygdala and its subregions. *NeuroImage*, 201, 115997.